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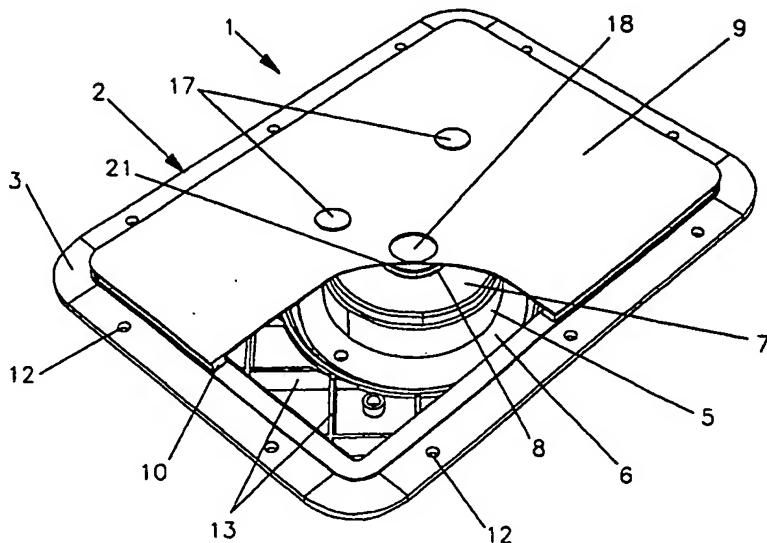


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(54) Title: LOUDSPEAKERS



(57) Abstract

A mid/high frequency loudspeaker drive unit comprising a stiff lightweight resonant panel form member, a housing in which the panel form member is mounted, a resilient suspension connected between the edges of the panel form member and the housing, the arrangement being such that the housing and the panel form member together define a sealed enclosure, and an electrodynamic exciter for applying bending wave energy to the panel form member to cause it to resonate to produce an acoustic output, the exciter comprising a magnet assembly rigidly fixed to the housing and defining an annular gap and a voice coil disposed in the annular gap and rigidly fixed to the panel form member near to the geometric centre thereof, the location of the voice coil in the annular gap being provided by the said resilient suspension.

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5

TITLE: LOUDSPEAKERS

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DESCRIPTIONTECHNICAL FIELD

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The invention relates to loudspeakers and more particularly to resonant panel loudspeakers, e.g. of the kind described in International patent application 20 WO97/09842, i.e. so-called distributed mode loudspeakers.

BACKGROUND ART

In the past there has been great difficulty in providing a loudspeaker covering the mid and high frequency audio range at high quality. Directivity varies greatly in 25 this range and extension to the highest frequencies is very difficult for mid driver alone. Typically two drivers are used with the expense and complication of a crossover network to divide the frequency range between them. The

crossover frequency is generally around 3kHz which is the most sensitive in human hearing which adds to the difficulty.

The concept of the present invention is to devise a 5 mid and high frequency driver which replaces the two convention drivers previously used, which does not crossover in the critical region and which has consistent, desirably wide directivity throughout its working range.

Distributed mode loudspeakers can be designed to 10 operate over some 8-Octaves of the audio frequency band, although this may not always be the best solution, for instance in hi-fi applications. It is envisaged that it might sometimes be appropriate for a distributed mode loudspeaker to be used in association with a subwoofer for 15 low frequencies, crossing over, say, at around 100 to 200 Hz.

There is therefore a need for a loudspeaker or at least a loudspeaker drive unit that is not meant to necessarily work over 8-Octaves but perhaps over 6 to 7 20 Octaves of the audio band, which would allow a wide choice of material and various construction possibilities that would help optimise the loudspeaker fully over its operating range. An example of this is a hi-fi midrange/tweeter drive unit working under the distributed 25 mode loudspeaker principle. This can bring significant benefits to a conventional boxed loudspeaker system by allowing the cross-over point to be designed away from the critical 3kHz area down to 1kHz range, typically 300-500 Hz

as well as benefiting from the superior radiation properties associated with a distributed mode loudspeaker.

There is also an expanding market in multimedia and computer peripherals for high performance compact speakers 5 and ever increasing demand for better sound and more compact construction for conventional televisions, monitors and flat panel televisions.

Thus there is a need for a structure that can be very compact and which can allow numerous features to be added 10 for performance enhancement, application versatility and cost saving.

The present invention provides a cost-effective vehicle for all such applications and allows a manufacturer to optimise on tooling outlay and its production processes.

15 The basic concept revolves around a simple construction of the loudspeaker "engine" or drive unit which would allow easy production assembly and provide consistency.

#### DISCLOSURE OF INVENTION

20 According to the invention there is provided a mid/high frequency loudspeaker drive unit comprising a stiff lightweight resonant panel-form member, a housing in which the panel-form member is mounted, a resilient suspension connected between the edges of the panel-form 25 member and the housing, the arrangement being such that the housing and the panel-form member together define a sealed enclosure, and an electrodynamic vibration exciter for applying bending wave energy to the panel-form member to

cause it to resonate to produce an acoustic output, the exciter comprising a magnet assembly rigidly fixed to the housing and defining an annular gap and a voice coil disposed in the annular gap and rigidly fixed to the panel-form member near to the geometric centre thereof, the location of the voice coil in the annular gap being provided by the said resilient suspension.

The bending stiffness of the panel-form member may be in the range 0.15Nm to 24Nm and is preferably in the range 10 2Nm to 9Nm.

The vibration exciter may be bonded to the panel-form member (herein after 'panel') and/or to the enclosure by way of injection moulding or by use of the adhesive. The vibration exciter voice coil may be bonded directly to a resonant panel during the injection moulding of the panel.

Alternatively the voice coil of an exciter may be bonded into a pre-formed aperture moulded in a resonant panel during assembly. The need for a separate voice coil carrier is thus removed.

20 The panel may be co-moulded with the suspension. The suspension may be of resilient a material, eg plastics.

The panel may be injection moulded as a monolith or using foaming techniques. The panel may be flat or curved and may vary in thickness or cross-section.

25 The enclosure may have embedded electrically conducting inserts for carrying electrical signals efficiently from connectors on the enclosure edge to the vibration exciter. The assembly and connectivity of the

drive unit may thus be automated.

The drive unit may be clad in other mouldings and structures to suit the application, e.g. for aesthetic reasons. For example an appropriate trim will make it 5 suitable for surface mounting onto a hi-fi speaker cabinet.

Conversely, a suitable outer moulding will turn the engine into a multimedia speaker. Further the engine may be mounted onto other structures such as television cabinets.

#### BRIEF DESCRIPTION OF DRAWINGS

10 The invention is diagrammatically illustrated, by way of example in the accompanying drawings, in which:

Figure 1 is a perspective view, partly cut-away to reveal hidden detail, of a loudspeaker drive unit;

Figure 2 is a cross-sectional side view of the 15 loudspeaker drive unit of Figure 1, and

Figure 3 is a graph representing the frequency response of the drive unit of Figures 1 and 2.

#### BEST MODE FOR CARRYING OUT THE INVENTION

In the drawings there is shown a loudspeaker drive 20 unit 1 intended as a mid/high frequency driver which may be used as a component in a loudspeaker system also comprising a low frequency driver, in which case the mid/high frequency and low frequency drivers may be assembled into a common cabinet, or as the sole driver in a compact 25 loudspeaker, e.g. for multi-media or computer or automobile use.

The drive unit 1 comprises a generally rectangular enclosure 2 having a dish-like body 11 surrounded by an

outwardly extending fixing flange 3 formed at intervals with holes 12 whereby the enclosure can be fixed in position by means of suitable fasteners (not shown) e.g. in the cabinet (not shown) of a loudspeaker. The enclosure 2 5 may be made from plastics, e.g. by injection moulding, and is formed internally with cross-bracing flanges 13 in the interests of adding stiffness to the enclosure while retaining its light-weight nature.

The enclosure 2 is formed at its base 14 with an 10 internal generally circular shallow recess 4 having a central through hole 16, the recess being adapted snugly to receive a circular backing plate 6 on which is rigidly mounted the magnet assembly 7 of an electrodynamic vibration exciter 5 by means of a bolt 20. The exciter 5 15 comprises the said magnet assembly which defines an annular gap 19, and a voice coil and cylindrical former assembly 8 disposed in the annular gap and moveable axially thereof in response to an electrical signal applied to the voice coil.

The backing plate 6 is fixed to the enclosure in any 20 convenient manner. Thus it may be fixed by fasteners or by adhesive means or may be moulded integrally with the enclosure.

Adjacent to the edge flange 3, a generally rectangular stiff, lightweight resonant panel-form member 9 is 25 resiliently mounted on the enclosure 2 by means of a flexible foam suspension 10 which extends round the periphery of the panel 9. The enclosure and the panel thus define a closed cavity 15. The suspension 10 may be fixed

to the panel 9 and to the enclosure 2 by adhesive means. The panel 9 is a distributed mode panel in accordance with the teaching in WO97/09842. The voice coil/former assembly 8 of the exciter 5 is rigidly fixed to the panel 9 at a 5 suitable near-centre drive position as taught in WO97/09842 to introduce bending wave energy into the panel to cause it to resonate to produce an acoustic output. The voice coil and coil former assembly 8 has an annular mounting member or foot 21, e.g. of plastics, rigidly fixed to its end 10 adjacent to the panel 9 to aid its fixing to the panel, which may be with the aid of an adhesive. It is to be noted that, unusually, the exciter 5 is grounded to the enclosure 2 and does not comprise a suspension between the magnet assembly and the voice coil so that centring of the 15 voice coil in the annular gap 19 of the magnet assembly is achieved only by the panel edge suspension 10. In this way the moving mass of the exciter is reduced to improve its high frequency response. The magnet assembly may be thermally coupled to the voice coil to improve its power 20 capacity and heat may be radiated from the exposed rear face of the backing plate 6.

Selective locally positioned small masses 17, e.g. in the range from about 2 to 12 grams are bonded to the panel to optimally tune the coupled resonances such that the 25 overall response is suitably tailored. This technique has the specific advantage of extending the low frequency range of the assembly. An aperture 18 through the panel 9 co-axial with the voice coil extends the high frequency

response. Some acoustic absorbent material (not shown) in the cavity 15 may be helpful in reducing the magnitude of higher order standing waves in the cavity, and may further refine the frequency response.

5 A drive unit as described above may have the following specification:-

Panel size = 210X148.5mm (A5 std. size)

Core = 3mm polycarbonate honeycomb, 3.5mm cell diameter

10 Skins = 100 $\mu$ m woven glass reinforced polycarbonate faceskins (0°/90° skin orientation) 50wt% glass

Bending stiffness = 5.6Nm

Areal density,  $\mu$  = 0.7kg/m<sup>2</sup>

Zm = 16Ns/m

15 Voice coil diameter = 26mm

Coil is positioned at standard distributed mode position (4/9, 3/7 = ratio)

Large ferrite ring magnet to improve BL and power handling.

20 As discussed, there is no suspension between the magnet and the voice coil and the panel is held in position by the foam suspension around the edge. The panel may be aligned and located accurately using the hole in the panel within the voice coil to assist alignment of the voice coil in the annular gap.

25 Locating pins might possibly be provided on the enclosure near to the panel edges to prevent sideways movement of the panel. The frequency response of this

panel is shown in Figure 3.

Smaller versions of the drive unit are envisioned with high quality piezo excitors which may extend the response into the ultrasonic range which could be  
5 useful in connection with new audio formats with a 50kHz or 100kHz sound bandwidth; this performance is beyond the compass of conventional pistonic technology.

#### INDUSTRIAL APPLICABILITY

10 The invention thus provides a novel loudspeaker drive unit for mid and high frequencies which solves significant problems in known arrangements both as concerns frequency cross-over problems and dispersion.

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CLAIMS

1. A mid/high frequency loudspeaker drive unit comprising a stiff lightweight resonant panel form member, a housing 5 in which the panel form member is mounted, a resilient suspension connected between the edges of the panel form member and the housing, the arrangement being such that the housing and the panel form member together define a sealed enclosure, and an electrodynamic exciter for applying 10 bending wave energy to the panel form member to cause it to resonate to produce an acoustic output, the exciter comprising a magnet assembly rigidly fixed to the housing and defining an annular gap and a voice coil disposed in the annular gap and rigidly fixed to the panel form member 15 near to the geometric centre thereof, the location of the voice coil in the annular gap being provided by the said resilient suspension.

2. A loudspeaker drive unit according to claim 1, wherein the enclosure comprises a dished body surrounded by a 20 fixing flange.

3. A loudspeaker drive unit according to claim 2, wherein the dished body comprises a through aperture and wherein the magnet assembly of the vibration exciter is rigidly mounted on the dished body whereby a part of its surface 25 closes the through aperture in the body.

4. A loudspeaker drive unit according to claim 3, comprising a recess in the dished body, and wherein the magnet assembly comprises a back plate mounted in the

recess in the dished body, the recess being formed with the through aperture.

5. A loudspeaker according to any proceeding claim wherein the resilient suspension is of foam material.

5 6. A loudspeaker drive unit according to any proceeding claim wherein the panel-form member comprises a core of honeycomb material sandwiched between skin layers and has a bending stiffness in the range 0.15 to 24Nm.

7. A loudspeaker drive unit according to claim 6, wherein 10 the bending stiffness is in the range 2 to 9Nm.

8. A loudspeaker drive unit according to any proceeding claim, comprising an aperture through the panel-form member and co-axial with and smaller than the diameter of the voice coil.

15 9. A loudspeaker drive unit according to any preceding claim, comprising at least one discrete mass mounted on the panel-form member and positioned to damp the low frequency response thereof.

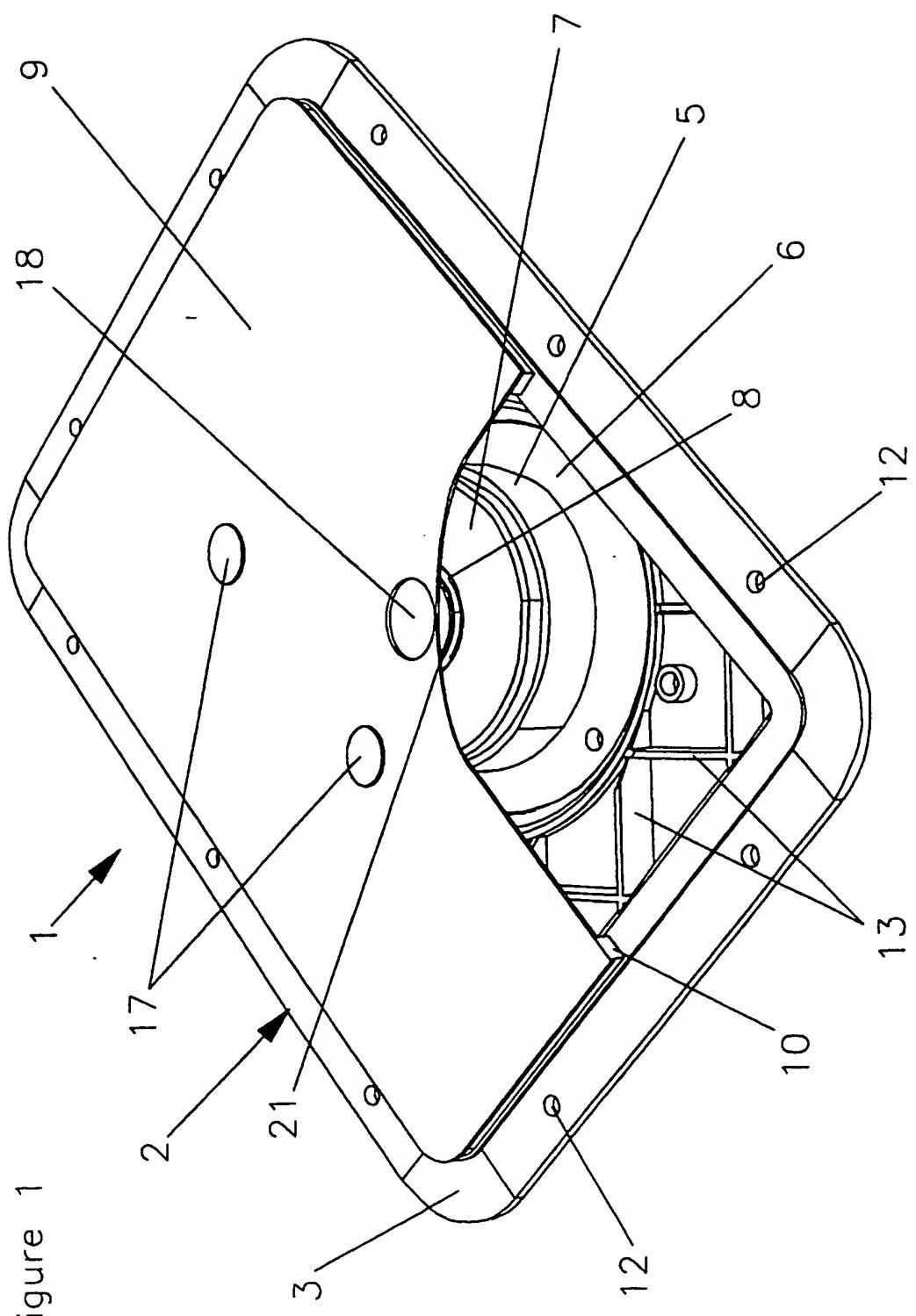
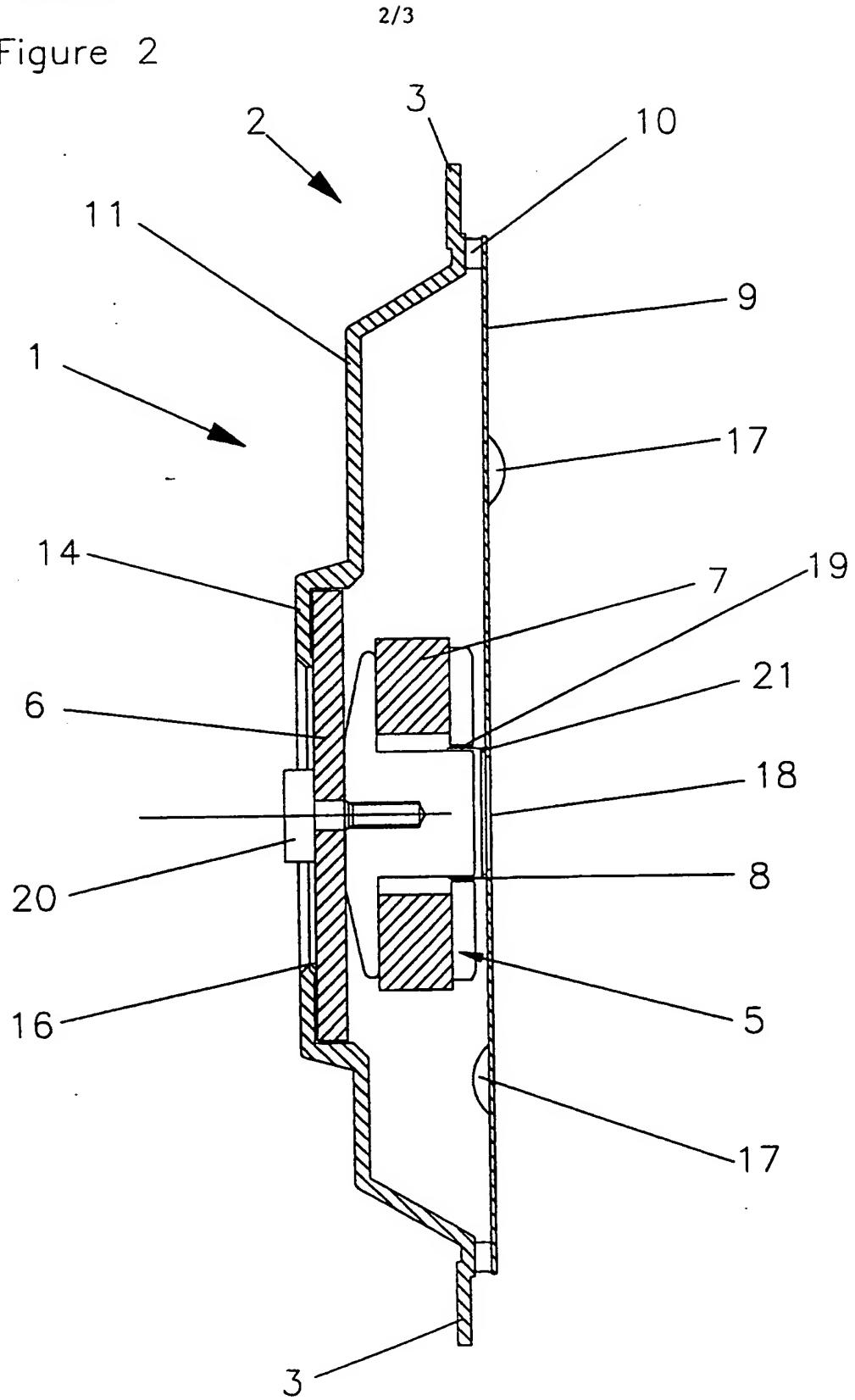


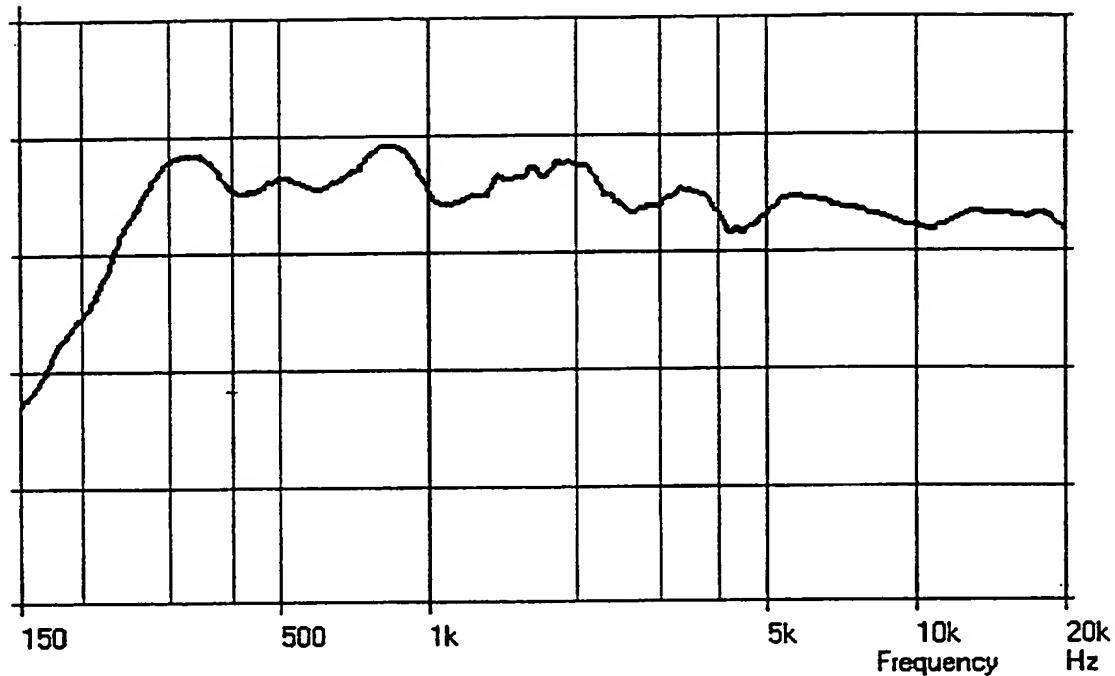
Figure 1

Figure 2



**Figure 3**

dB



## INTERNATIONAL SEARCH REPORT

In International Application No  
PCT/GB 99/03209

A. CLASSIFICATION OF SUBJECT MATTER  
IPC 7 H04R7/06 H04R7/20 H04R9/04 H04R1/28

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Further documents are listed in the continuation of box C.

Patent family members are listed in annex.

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Date of the actual completion of the International search

28 March 2000

Date of mailing of the International search report

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## INTERNATIONAL SEARCH REPORT

International Application No

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